Geography, Environment, and Climate: the “Real” Real Shocks

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Geography, Environment, and Climate

- 3 aspects, tightly connected (GEC).
- How can be related with history and economic growth?
- How do GEC affect humans?
- More interestingly even, how do humans affect GEC?
- Not your traditional geography or social studies class back in High School.

- Modern study in economics and in history:
  1. New growth theory.
  2. Environmental history.
Figure 15.7
Natural Capital Versus GDP per Capita

GDP per capita, 2000 (ratio scale)

Natural capital per capita, 1997 (ratio scale)
Geography

Examples:

1. Europe is 1/8th of the size of Africa but coastline is 50% longer.


3. De Gaulle’s memoirs: the interests and policies of the United States, Britain, and France will never completely coincide; the United States, as a continent, always tending to think in terms of air power; Britain, as an island, in terms of naval power; and France, in terms of land power.

Let’s look at a world map.
Figure 15.1
Relationship Between Latitude and Income per Capita

GDP per capita, 2000 (ratio scale)

Latitude (absolute degrees distant from the equator)

Source: Heston et al. (2002).
Figure 15.5
Latitude Versus Agricultural GDP per Agricultural Worker

Agricultural GDP per agricultural worker, 2000 (ratio scale)

**Figure 15.2**
Regional Variation in Income and Access to the Sea

![Graph showing regional variation in income and access to the sea.

GDP per capita, 1995

- $25,000
- $20,000
- $15,000
- $10,000
- $5,000
- 0

Percentage of population with access to the sea

- Western Europe
- East Asia
- Sub-Saharan Africa
- Latin America
- South Asia
- Eastern Europe and former Soviet Union

Traditional Geographical Explanations

- Climate. Montesquieu, The Spirit of the Laws (1748) (he was a wine grower). Cold climate are good for growth, warm climates are bad: North Europe was a backwater region until the late middle ages. Comparison with Fertile Crescent and Nile valley.

- Low land river valleys in dry climates:
  1. Problems with Fertile Crescent: food production appears in hills. States and bureaucracy only follow agriculture by some time.

- Geopolitics: Mackinder, Tahan, Kjellén, Haushofer.
Possibility I: Political Division is Good

Eric Jones, *The European Miracle (2003)*

⇒ geography again, hypothesis 1.

- We already argued that China versus Europe.
- Why is political division good?

1. Competition.
2. Robustness.
Empirical Evidence I: China

- Emperor Qiánlóng (1736-1799) ordered the compilation of the most famous works of the Chinese past: *Four Treasuries* (classics, history, philosophy, literary works).

- Enormous work: 36,000 manuscript volumes.

- To do so, private libraries were searched.

- Taking advantage of the opportunity, several types of books were destroyed:
  1. Books that implied resistance against the Manchu rule of China.
  2. Books on geography or travel that could give inside information on China’s defenses.
  3. Books that exposed philosophical interpretations of the classics that were different from ones preferred by the scholars at the court.

- We know of over 2000 titles that were destroyed and that now are likely lost forever.

- This is actually not the only time in China’s history: First Emperor’s *Burning of the Books and Burying of the Intellectuals.*
Empirical Evidence II: Florence

- Arrival of Arab numbers (that are actually Indian numbers) to Europe in the 13-th century.

- Fantastic new technology.

- Florence opposed it. Arte del Cambio code in 1299 explicitly prohibited Arab numbers. Why?

- However, soon Florence bankers were dominated by bankers in other cities.
Possibility II: China’s Endowments are Bad


⇒ geography again, hypothesis 2.

- Coal:
  1. Far away from production centers.
  2. Steam engine versus ventilations.

- Environmental limits.

- Pacific is bigger than Atlantic.
An Empirical Application

- How is the evolution of population growth and technological Change since 1 Million BCE?

- Basic lesson so far: growth depends on technology progress.

- Intuition: more people probably must imply higher knowledge accumulation.

- Growth and population may be closely link.

- Empirical evidence.
A Simple Model

- Production function: we produce output with land, labor, and technology

- Technology progress depends on how many people we have.

- Malthusian assumption: we will reproduce (or die) until we reach a certain level of income.

- Therefore, bigger land surfaces should sustain more people \( \Rightarrow \) more technology \( \Rightarrow \) more people.
A first look at the data.

Regression:

\[ n_t = -0.0026 + 0.524 L_t \]

\[ R^2 = 0.92, \quad D.W = 1.10 \]

Robust to different data sets and specifications.
Cross-Section Evidence

- World population was separated from 10,000 BCE to circa 1500.

- Population and Population Density *circa* 1500:

<table>
<thead>
<tr>
<th></th>
<th>Land Area</th>
<th>Population</th>
<th>Pop/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Old World”</td>
<td>83.98</td>
<td>407</td>
<td>4.85</td>
</tr>
<tr>
<td>Americas</td>
<td>38.43</td>
<td>14</td>
<td>0.36</td>
</tr>
<tr>
<td>Australia</td>
<td>7.69</td>
<td>0.2</td>
<td>0.026</td>
</tr>
<tr>
<td>Tasmania</td>
<td>0.068</td>
<td>0.0012-0.005</td>
<td>0.018-0.074</td>
</tr>
<tr>
<td>Flinders Islands</td>
<td>0.0068</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- England *versus* Europe and Japan *versus* Asia.
Changing the Environment: the Columbian Exchange

- Environment can be modified: the Columbian Exchange.

- Transfers of plants, animals, and microbes among the Americas, Europe, Asia, and Africa.

- Some of it was voluntary, some involuntary.

- Alfred Crosby, *The Columbian Exchange* and *Ecological Imperialism*.

- Breaks hundreds of thousands of years of separate evolutionary changes.
Euroasia to America


2. Fruits: banana, watermelon, coconut, mango, apple, pear, apricot, peach, plum, cherry, citrus, olive.


4. Work animals: Horse, camel, water buffalo.

5. Farm animals: cow, pig, chicken, goat, sheep, goose.


7. Coffee, tea, and sugar (white gold, Canada versus Guadeloupe in 1763).

8. Microbes: bubonic plague, chicken pox, cholera, influenza, leprosy, malaria, measles, scarlet fever, smallpox, typhoid, typhus, yellow fever.
America to Euroasia

1. Maize (first for livestock feeding, later human consumption).
2. Other staples: sweet potatoes, potatoes, manioc (remember Malthusian model?).
3. Vegetables: tomatoes, chili pepper, bell pepper, bean, squash.
4. Peanut, sunflower, cashew, pecan.
5. Fruits: blueberry, huckleberry, pineapple, pumpkin, avocado.
7. Rubber.
8. Animals: turkey, llama, guinea pig.
10. Syphilis.
Table 1: Consumption of colonial luxuries in Europe, early modern period (lbs per head and year)

<table>
<thead>
<tr>
<th></th>
<th>Sugar</th>
<th>Coffee</th>
<th>Tea</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1670n</td>
<td>2.2</td>
<td>0.1</td>
<td>1722</td>
</tr>
<tr>
<td>1700-9</td>
<td>5.7</td>
<td>0.1</td>
<td>1750-9</td>
</tr>
<tr>
<td>1780-9</td>
<td>11.0</td>
<td>0.1</td>
<td>1804-9</td>
</tr>
<tr>
<td>1770-9</td>
<td>23.1</td>
<td>0.5</td>
<td>1844-9</td>
</tr>
<tr>
<td>Belgium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1850</td>
<td>3.6</td>
<td>0.1</td>
<td>1720-9</td>
</tr>
<tr>
<td>1850-4</td>
<td>6.8</td>
<td>0.1</td>
<td>1850-4</td>
</tr>
<tr>
<td>1790-4</td>
<td>1.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1783-90</td>
<td>2.1</td>
<td>0.5</td>
<td>1825-34</td>
</tr>
<tr>
<td>1830</td>
<td>4.4</td>
<td>0.5</td>
<td>1835-44</td>
</tr>
<tr>
<td>Austria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1800</td>
<td>0.3</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>1680</td>
<td>0.9</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>1820</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 2: Real Sugar Prices and Sugar Consumption Per Capita in England, 1600-1850
Figure 3: Real Tea Prices and Consumption Per Capita in England, 1600-1850
Figure 4: Real Coffee Price and Consumption Per Capita in England, 1600-1850
Table 3: Welfare gains from sugar, tea, and coffee, England (1600-1850)

<table>
<thead>
<tr>
<th>New Good</th>
<th>Year Range</th>
<th>EV</th>
<th>CV</th>
<th>(\nu)</th>
<th>(\rho)</th>
<th>(\delta)</th>
<th>(R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A. Results with (\rho) calibrated at 0.03985</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>1600-1850</td>
<td>5.0%</td>
<td>7.6%</td>
<td>0.0093</td>
<td>0.9906</td>
<td>0.0435</td>
<td>0.8317</td>
</tr>
<tr>
<td>Tea</td>
<td>1600-1850</td>
<td>7.9%</td>
<td>7.3%</td>
<td>0.0572</td>
<td>0.9395</td>
<td>0.3490</td>
<td>0.7718</td>
</tr>
<tr>
<td>Coffee</td>
<td>1600-1850</td>
<td>1.5%</td>
<td>1.5%</td>
<td>0.1286</td>
<td>0.9306</td>
<td>0.5875</td>
<td>0.6503</td>
</tr>
<tr>
<td>Welfare Gain</td>
<td></td>
<td>17.2%</td>
<td>10.4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel B. Results with 0 &lt; (\rho) &lt; 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>1600-1850</td>
<td>6.4%</td>
<td>6.2%</td>
<td>0.0600</td>
<td>0.7216</td>
<td>0.3206</td>
<td>0.6594</td>
</tr>
<tr>
<td>Tea</td>
<td>1600-1850</td>
<td>13.6%</td>
<td>11.3%</td>
<td>0.1550</td>
<td>1.4894</td>
<td>0.3711</td>
<td>0.5026</td>
</tr>
<tr>
<td>Coffee</td>
<td>1600-1850</td>
<td>2.9%</td>
<td>3.0%</td>
<td>0.3657</td>
<td>2</td>
<td>0.2991</td>
<td>0.9571</td>
</tr>
<tr>
<td>Welfare Gain</td>
<td></td>
<td>23.9%</td>
<td>20.40%</td>
<td></td>
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</tr>
</tbody>
</table>

Notes: The parameter values of \(\nu\), \(\rho\), and \(\delta\) are calibrated by choosing values that minimize sums of squared error between predicted and actual new good consumption. In panel A, \(\rho\) is fixed at 0.03985 and only \(\nu\) and \(\delta\) are chosen. EV refers to equivalent variation and CV to compensating variation. The parameter \(\delta\) is the weight on utility from new good consumption, \(\frac{1}{\rho}\) is the intertemporal elasticity of substitution, and \(\nu\) is the new good utility shift.
<table>
<thead>
<tr>
<th>Good</th>
<th>Welfare Gain</th>
<th>Year</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modern Goods</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple Cinnamon Cheeses</td>
<td>0.002%</td>
<td>1992</td>
<td>Hausman (1996)</td>
</tr>
<tr>
<td>Personal computers</td>
<td>3.5–4%</td>
<td>2004</td>
<td>Kopercky &amp; Greenwood (2009)</td>
</tr>
<tr>
<td>Minivans</td>
<td>0.03%</td>
<td>1998</td>
<td>Petrin (2002)</td>
</tr>
<tr>
<td>Satellite TV</td>
<td>0.04–0.06%</td>
<td>2001</td>
<td>Goolsbee &amp; Petrin (2004)</td>
</tr>
<tr>
<td>Internet</td>
<td>2–3%</td>
<td>2006</td>
<td>Goolsbee &amp; Klenow (2005)</td>
</tr>
<tr>
<td>Mobile phones</td>
<td>0.48–0.5%</td>
<td>1999</td>
<td>Hausman (1999)</td>
</tr>
<tr>
<td><strong>Colonial Luxuries</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>7.56–8.03%</td>
<td>1600–1850</td>
<td>this study</td>
</tr>
<tr>
<td>Tea</td>
<td>7.28–7.85%</td>
<td>1600–1850</td>
<td>this study</td>
</tr>
<tr>
<td>Coffee</td>
<td>1.45–1.54%</td>
<td>1690–1850</td>
<td>this study</td>
</tr>
</tbody>
</table>

Notes: Welfare results from this study are generated using Clark data with preferred μ calibration.
* For Inflation cases.
Climate in History

Three basic observations:

1. Climate changes across different areas.
2. Climate changes over time.
3. Widespread consensus that part of this change is due to human agency.
<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Description</th>
<th>Representative Cities</th>
<th>Percentage of World Landmass</th>
<th>Percentage of World Population</th>
<th>GDP per Capita Relative to World Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Af</td>
<td>Tropical Rainforest</td>
<td>Jakarta, Indonesia Manaus, Brazil</td>
<td>4.0</td>
<td>4.4</td>
<td>0.64</td>
</tr>
<tr>
<td>Am</td>
<td>Tropical Rainforest with Seasonal Monsoon</td>
<td>Manila, Philippines Cochin, India Belém, Brazil</td>
<td>0.8</td>
<td>2.4</td>
<td>0.41</td>
</tr>
<tr>
<td>Aw</td>
<td>Tropical Savannah</td>
<td>Dhaka, Bangladesh Kinshasa, Congo Havana, Cuba</td>
<td>10.8</td>
<td>17.5</td>
<td>0.38</td>
</tr>
<tr>
<td>Cw</td>
<td>Subtropical: Mild Humid with Dry Winter</td>
<td>Hanoi, Vietnam Kanpur, India Lilongwe, Malawi</td>
<td>4.3</td>
<td>16.0</td>
<td>0.44</td>
</tr>
<tr>
<td>Cf</td>
<td>Mild Humid Climate with No Dry Season</td>
<td>New York, USA Paris, France Shanghai, China Sydney, Australia</td>
<td>7.7</td>
<td>19.5</td>
<td>2.24</td>
</tr>
<tr>
<td>Cs</td>
<td>Mediterranean Climate: Mild, Humid with Dry Summer</td>
<td>San Francisco, USA Rome, Italy Santiago, Chile</td>
<td>2.2</td>
<td>4.3</td>
<td>2.10</td>
</tr>
<tr>
<td>Df</td>
<td>Snowy-Forest Climate with No Dry Season</td>
<td>Chicago, USA Moscow, Russia</td>
<td>23.0</td>
<td>5.8</td>
<td>1.90</td>
</tr>
<tr>
<td>Dw</td>
<td>Snowy-Forest Climate with Dry Winter</td>
<td>Seoul, South Korea Vladivostok, Russia</td>
<td>6.2</td>
<td>5.3</td>
<td>0.64</td>
</tr>
<tr>
<td>BS</td>
<td>Semi-arid Steppe</td>
<td>San Diego, USA Odessa, Ukraine</td>
<td>12.3</td>
<td>11.8</td>
<td>0.55</td>
</tr>
<tr>
<td>BW</td>
<td>Desert; Annual Precipitation Less than 15 in. (38 cm)</td>
<td>Cairo, Egypt Karachi, Pakistan</td>
<td>17.3</td>
<td>6.2</td>
<td>0.58</td>
</tr>
<tr>
<td>H</td>
<td>Highlands</td>
<td>Mexico City, Mexico</td>
<td>7.3</td>
<td>6.8</td>
<td>0.78</td>
</tr>
<tr>
<td>E</td>
<td>Ice Climates; Average Temperature in Warmest Month Less Than 50°F (10°C)</td>
<td>Nuuk, Greenland</td>
<td>4.0</td>
<td>&lt;0.1</td>
<td>—</td>
</tr>
</tbody>
</table>

Source: Data on landmass, population, and GDP per capita are from Mellinger, Sachs, and Gallup (1999).
Ice Age Temperature Changes

EPICA

Vostok

Ice Volume

Thousands of Years Ago
Reconstructed Temperature

Medieval Warm Period

Little Ice Age

Temperature Anomaly (°C)
The Vikings’ Voyage to the New World

- **850**: L’Anse aux Meadows
- **960**: c. 874 - The Norse colonize Iceland.
- **960**: c. 960s - Erik the Red’s father is banished from Norway to Iceland.
- **986**: c. 986 - Erik the Red, banished from Iceland, colonizes Greenland.
- **990**: c. 1000 - Vikings reach Newfoundland and possibly points further south.
Climate in Europe

- Winters cold enough to wipe out germs, but not too cold. High humidity. Constant rain (Orbayu).

- Dry summers.

- Gulf Stream: the presence of Brazil forces the hot water up in the Ocean and Greenland’s waters stops it in the north.

However:

1. Too many forests (Grimm Brothers), difficult to cultivate until iron ax.
2. Hard soils, not enough rain in summer: fallow.
3. Need animals for plowing and manure.

Consequences: diet rich in wheat and animal protein (meat and dairy products).

- Mediterranean sea.
Winds in Mediterranean
Climate in Asia

- **Interior** ⇒ grasslands that supported Nomads.

- **Exterior** ⇒ monsoon:
  1. Much less need to fallow.
  2. Possible to cultivate rice in large parts of Asia.

- **Consequences:**
  1. Much higher density.
  2. Less cows, more pigs and chicken.
Climate

• One fundamental observation: it is much easier to warm up than to cool down.

• Warm up:
  1. Evidence of human ancestors control of fire between 1.8 to 1 million years ago.
  2. Clothing probably existed around 250,000 years ago, when H. Neanderthalensis had to survive winters in Europe.

• Cool down:
  1. Romans circulated aqueduct water through their walls to reduce heat.
  2. Use of water imitated by other times: Persians, Arabs, etc.
  3. Modern electrical air conditioning was invented in 1902 by Willis Haviland Carrier (his company, Carrier, is still a leading producer worldwide)
     1. First industrial application: 1906, Chronicle Cotton Mills of Belmont, NC.
     2. First house with A/C: 1914, Charles Gates’ mansion in Minneapolis ($1 million).
Consequences I

- Much easier to populate and work on very cold areas than in very hot areas.

- Expansion of the U.S. in the 19th century: much faster in the North than in the South.

- Reversal in the second half of the 20th century: Buffalo versus Atlanta.


- Political economic consequences.
Consequences II

- Tropical diseases are highly damaging and difficult to fight.
- New England: winter kills all germs.
- Different patterns of economic, social, and political life.
Figure 15.6
Malaria Ecology Versus Incidence of Malaria

Percentage of the population at risk for malaria, 1994

- Nigeria
- Ghana
- Burkina Faso
- Papua New Guinea
- Thailand
- Pakistan
- India
- Colombia
- Mexico
- Syria
- Brazil
- Mauritius
- United States
- Italy
- Spain
- Greece
- Finland
- Belgium
- Netherlands

Malaria ecology index (ratio scale)
Geography Determines Political Structure


- Former European colonies have performed very differently: U.S. versus Belize.
- Not clear correlation with former colony.
- Differences in settlers mortality induced different institutions.
- Differences in outcomes:
  1. British America: 9 universities for 2.5 million people.
  2. Spanish and Portuguese America: 2 universities for 17 million people.
### IV Regressions of log GDP per capita

<table>
<thead>
<tr>
<th></th>
<th>Base Sample</th>
<th>Base Sample without neo-Europes</th>
<th>Base Sample without neo-Europes</th>
<th>Base Sample without Africa</th>
<th>Base Sample with Continent Dummies</th>
<th>Base Sample with Continent Dummies</th>
<th>Base Sample, dep. var. is log output per worker</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Two Stage Least Squares</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Average Protection Against</td>
<td>0.94</td>
<td>1.00</td>
<td>1.28</td>
<td>1.21</td>
<td>0.58</td>
<td>0.58</td>
<td>0.98</td>
</tr>
<tr>
<td>(0.16)</td>
<td>(0.22)</td>
<td>(0.36)</td>
<td>(0.35)</td>
<td>(0.10)</td>
<td>(0.12)</td>
<td>(0.30)</td>
<td>(0.46)</td>
</tr>
<tr>
<td>Expropriation Risk 1985-1995</td>
<td>-0.65</td>
<td>0.94</td>
<td>0.04</td>
<td>-1.20</td>
<td></td>
<td></td>
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<tr>
<td>(1.34)</td>
<td>(1.46)</td>
<td>(0.84)</td>
<td></td>
<td>(1.8)</td>
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<tr>
<td>Asia Dummy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.92</td>
<td>-1.10</td>
<td>(0.40)</td>
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<tr>
<td>(0.40)</td>
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<td></td>
<td></td>
<td></td>
<td>(0.52)</td>
<td></td>
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</tr>
<tr>
<td>Africa Dummy</td>
<td>-0.46</td>
<td>-0.44</td>
<td></td>
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<tr>
<td>(0.36)</td>
<td>(0.42)</td>
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</tr>
<tr>
<td>&quot;Other&quot; Continent Dummy</td>
<td>-0.94</td>
<td>-0.99</td>
<td></td>
<td></td>
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<td></td>
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